International Network on Climate Change

Project Results & Proceedings of Summer-School

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Understanding Adaptation and Mitigation Strategies of Andean People

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“*... el tiempo ya no es como antes...*”

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This publication summarizes the main results of the INCA-Project during 2011/2012 and the contributions to the according INCA-Summer-School, which took place from September 19th – September 27th 2012 at the Technische Universität Dresden, Faculty of Environmental Sciences, Institute of International Forestry and Forest Products, Professorship of Tropical Forestry in Tharandt, Germany.

An international network on climate change impacts on small farmers in the tropical Andes – global conventions from a local perspective

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André Lindner[*] & Jürgen Pretzsch[*]

Abstract

The agricultural sector of Andean countries like Peru and Bolivia perceives the consequences of climate change in increasing water stress due to melting glaciers and changing precipitation patterns. Therefore mainly subsistence agricultural systems are increasingly vulnerable. Traditional inhabitants of the tropical Andean region are aware of the recurrent diversity of climate related impacts and its consequences, thus livelihood strategies are based on principles of risk management. Andean farmers are nowadays applying traditional strategies in a combination of homegrown experimentation and scientific know-how to cope with and adapt to a changing climate. Understanding these adaptations has become one of the most important aspects of research into climate change impacts and vulnerability. It provides essential knowledge for developing and transferring strategies towards a sustainable management in agriculture and agroforestry systems. But there still is a lack of a comparative assessment, especially in regions with high impact of extreme climate conditions. The endogenously determined strategies, which are based on the experience of the farmers, are to be complemented by knowledge and experiences coming from outside farm-household systems and communities. In a collaborative way, this exogenous knowledge is to be placed at

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the disposal of local actors. The necessary network approach leads to a comprehensive involvement of local stakeholders. Therefore a participative network on climate change may work as a tool to bridge the gap between the global discourse on climate change and local action.

Keywords: adaptation, agroforestry, livelihood strategies, research and development, sustainability, vulnerability

1. Introduction

Being the longest continental mountainous region in the world, the Andes are an about 7.000 km long continual range along the west coast of the South American subcontinent. They extend through seven countries including Peru and Bolivia. Here an international network of Peruvian, Bolivian and German partners was formed to investigate climate change impacts on small farmers (Fig. 1).

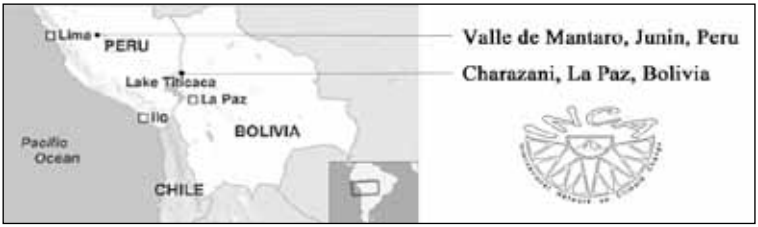

Figure 1. Two current research sites of the International Network on Climate Change in the Andes of Peru and Bolivia

Despite the fact that climate change in high elevation tropical mountain ranges, like the Andes, is not well represented in recent General Circulation Models (GCM), local climate models show increased warming with a more distinct increase in temperature at

higher elevations (Solman et al. 2008; Urrutia and Vuille 2009). The tropical Andes are characterized by the diversity of their ecosystems. Therefore the consequences of a changing climate are of increased concern, due to the effects that alterations within those ecosystems will have on human population, directly dependent on the services they provide (Vuille et al. 2008). Thus, for people living in the tropical Andes, climatic change is not a problem of the future - it's already there. Countries like Peru and Bolivia are already bearing the consequences of climate change, such as retreat of glaciers and extreme weather events, which are directly affecting crops, livestock, biodiversity, and, last but not least, increasing levels of poverty (Vuille et al. 2003). Almost the entire agricultural sector is mainly suffering from increasing water stress due to melting glaciers and changing precipitation patterns. The productivity, especially of small-scale subsistence oriented production systems is threatened, and thus the livelihood of smallholders is at risk (McDowell and Hess 2012).

As traditional inhabitants of the tropical Andean region, these farmers historically have had to cope with extreme daily temperatures, unpredictable weather events from one year to the next, and a diversity of environmental conditions scattered across the elevations. Therefore locals are aware of the recurrent diversity of climate related impacts and its consequences (Fig. 2). Nonetheless climate change, functioning as an additional driver of ecosystem change and cause of shifts of resource use, brings another dimension. In the end the effects of a rapidly changing climate could jeopardize tropical Andean ecosystems and their capacity to provide ecosystem services (Anderson et al. 2011). Despite the climatic variability and the sometimes harsh conditions, the tropical Andean region is one of the first intensive agricultural societies in the world in which a manifold selection of crops was domesticated and adapted to high altitude environments and extreme climate fluctuations. Along with the availability of these

crops, techniques were evolving to cope with such environmental constraints. Among those are complex agroforestry systems, agricultural terraces, artificial swamps, and raised fields (e.g. Erickson and Candler 1989; Lhomme and Vacher 2003).

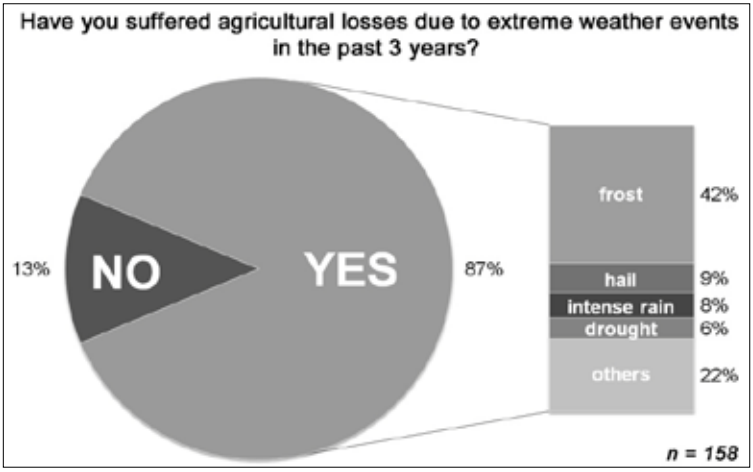

Figure 2. Responses out of 158 household interviews, conducted during a survey by the International Network on Climate Change in 2010 in the Achamayo watershed, Valle de Mantaro, Peru (Vidal-Merino et al. 2012)

However, shifts in ecosystem services related to agricultural production could occur as a consequence of climate change and changing pattern of human settlement (Anderson et al. 2011). In the Andean region the permanent pressure to cope with shocks, and resource maximization, while diversification, linkage to markets and networking is a driver towards livelihood strategies, which are based on principles of risk management. This an essential point in contributing to the resilience of family livelihood development (Valdivia et al. 2010). Nowadays smallholders are applying these traditional strategies in a combination of homegrown experimentation and scientific know-how to adapt to climate change (Salick and Ross 2009). Understanding these adaptations has

become one of the most important focuses of research into climate change impacts and vulnerability, since it provides essential knowledge for developing and transferring strategies towards a sustainable management in agriculture and agroforestry (Pretzsch 2005; Morton 2007; Howden et al. 2007; Boomiraj et al. 2010). However, so far there still is a lack of information about the related local knowledge, behavior and action. Therefore a comparative assessment is needed, especially in regions with high impact of extreme climate conditions (Chhatre and Agrawal 2009). The endogenously determined strategies, which are based on the experience of the famers, are to be complemented by knowledge and experiences coming from outside farm-household systems and communities. In a collaborative way, this exogenous knowledge is to be placed at the disposal of local actors. Thus a participative network on climate change contributes to bridge the gap between the global discourse on climate change and local action. The necessary network approach leads to a far reaching involvement of the local actors.

2. The concept of an International Network on Climate Change

The establishment of an International Network on Climate Change follows a nonlinear, interactive and iterative process. The main objective of the network is to understand the situation of local farming and forestry systems in the tropical Andes, deriving and testing livelihood strategies for small farms and indigenous communities together with local actors, scientists, experts, and students. Furthermore, the network contributes to transfer of technology and knowledge among all members.

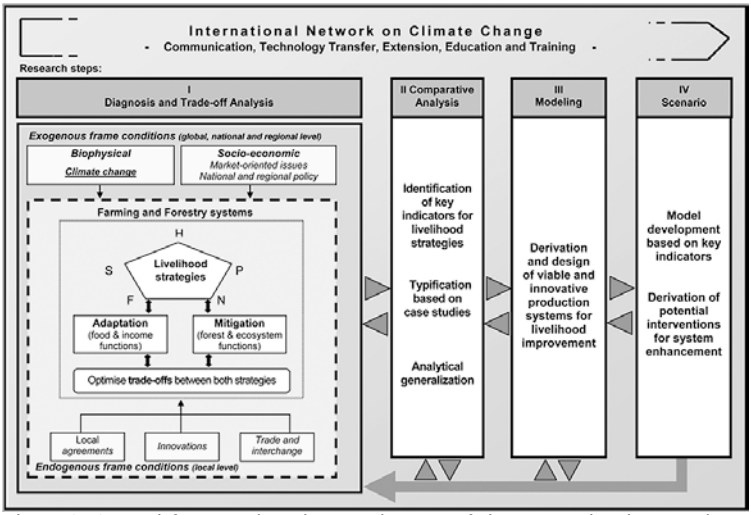

Figure 3. General framework and research steps of the International Network on Climate Change

The specific objectives of the climate change network are:

i. To organize and integrate in a Research & Development oriented network of relevant stakeholders on the topic of adaptation and mitigation on climate change in exemplary rural areas of the tropical Andes

ii. To conduct an analysis of the biophysical and socio-economic factors that influence livelihood strategies of traditional Andean farmers and to study how these systems are being affected by climate change

iii. To compare case study outcomes in order to generate and typify key indicators for livelihood strategies in the tropical Andean region and to comparatively assess trade-offs between the options that enhance food and income functions (adaptation strategies) and those options that enhance the ecosystem functions (mitigation strategies)

iv. To elaborate models for the simulation and planning of successful interventions in farming and forestry systems in order to improve adaptation and mitigation strategies
v. Scientific exchange of adaptation and mitigation strategies on climate change among local users, scientific community, state authorities, NGOs, as well as other relevant stakeholders in the tropical Andean region
vi. To contribute to the international debate within the UNFCCC (United Nations Framework, Convention on Climate Change) from the bottom up to consider the needs and experiences of local stakeholders in using natural resources

The network follows a Research & Development (R&D) approach, integrating case study based research, modeling, scenarios, extension and training. The profound understanding of the farming and forestry systems and the behavior of the local actors is a necessary precondition to identify subsequent R&D network activities toward a local strategy for adaptation to and mitigation of climate change and its impacts.

The international network on climate change involves two strongly interrelated components: (1) communication, technology transfer education, training, which permits the involvement of all relevant actor groups in the stages from assessment to networking; (2) a participatory research and diagnosis process and modeling to cope with climate change effects. In this context an innovative element is the “social learning approach” (Rist et al. 2006), which is realized through socio-economic field laboratories. This approach combines a wide range of participative methods to be applied within the communities: a holistic diagnosis based on a rapid rural appraisal (Chambers 1994) with focus on the resource status, the socio-economic and cultural conditions and on land-use practices; a subsequent joint analysis of strengths, weaknesses, opportunities

and threats (SWOT) is conducted to evaluate the findings. At this juncture the main focus is put on the farming and forestry systems of local Andean people and their livelihood strategies to cope with climate change. To understand these strategies, the general performance of the farm will be assessed, including the knowledge of farmers and family members related to the ongoing production, production alternatives and their effects on climate change. The applied approach follows four main steps, as shown in Figure 3: The initial analytical steps are based in the classical Farming System Analysis and Research (Collinson 2000), which has been further developed and applied to forestry systems. The interaction between the farming and forestry system analysis and the livelihood approach will permit the extraction and understanding of the vulnerability factors which determine living conditions and strategies of the affected farmers (Pretzsch 2005). The livelihood approach is based on five forms of livelihood assets or types of capital: natural capital, social capital, financial capital, physical capital and human capital (e.g. Scoones 1998; DFID 1999). In a proximate comparative analysis key indicators of those capitals will be analyzed and trade-offs between different goals and production alternatives will be assessed. Experiences with trade-off analysis show that for a given set of resources and technology, obtaining more of a desirable outcome from a system, less from another desirable outcome (or more of an undesirable outcome) is required (Stoorvogel et al. 2004). Thus trade-offs imply a sacrifice or opportunity cost in terms of benefits foregone (Grimble and Wellard 1997). The portfolio of the farmer might shift between short term food security while taking in account a certain degree of degradation; medium term climate change adaptation with crop variation including agroforestry options; and the integration of trees or long term carbon storage with a focus on permanent cultures. The fourth and final step therefore focuses on the development of

models and finally on the derivation of potential interventions for system enhancements.
In this regard agroforestry systems offer important opportunities for creating such synergies or desirable trade-offs. The promotion of agroforestry systems can contribute a reduction in the vulnerability of small-scale farmers and help them to adapt to climate change (Verchot et al. 2007).

3. The outlook on an endogenous approach

Furthermore, large parts of the Andean region are mainly inhabited by rural population dependent on subsistence agriculture and at the same time are areas with a social vulnerability that increases constantly due to degradation of the ecosystem caused by social and climatic change. There is an increasing vulnerability in terms of food security, which basically occurs as a result of the accumulation the small sized properties and a low level of economic diversification (Espinosa and Bacerra, 2008). This situation made local authorities, governmental and nongovernmental organizations aware to take action and contribute to the improvement of quality of life in the region based on the traditional knowledge and local experience on resources management. New technologies and contemporary knowledge available have to be taken into account. In this regard *Endogenous Sustainable Development* is defined as the development from inside, taking cultural values as well as external knowledge in consideration (Molenaar 2006). Additionally, endogenous development theory suggests that communities are more likely to remain cohesive and sustain their traditions, cultures, spirituality, and natural resources when they develop their future collectively and base their plans on the resources available within the community (Holly and Harry, 2012). According to this baseline there is an unknown potential adaptive capacity that needs to be assed and to be linked directly to the culture and the environment.

As every community is been affected in different way by climate change (Füssel, 2010) there is a need for site and situation specific stressor- and problem-assessment as exemplified in Table 1.

Indeed, the complexity of the situation challenges households and communities as well as governmental and non-governmental organizations to develop an adequate adaptive capacity along the Andes. Some recent international studies have highlighted the adaptation strategies and capacity that communities use to cope with climate change (e.g. Vuille et al. 2008; McDowell and Hess 2012; Nethononda et al. 2013). Nevertheless more efforts are needed to make use and learn from these examples and communicate the advantages and disadvantages of certain strategies and scenarios in the face of climate change. Therefore the targeted outcomes of the International Network on Climate Change are the establishment of trans- and interdisciplinary working groups on climate change to strengthen research capacities, the development of models to understand and predict the strategies of small farmers in the Andes to cope with a changing climate and academic education as well as extension actions at local community level.

Thus the main intention of the International Network on Climate Change is to understand the situation of local farming and forestry systems in the tropical Andes, deriving and testing livelihood strategies for small-scale farms and indigenous communities, together with local actors, scientists, experts, and students. The network contributes to transfer of technology and knowledge among all members and bridges the gap between the global discourse on climate change and local action. The project concept introduced here might work as a model for similar approaches in different regions or as baseline for continuative initiatives.

Tabel 1. Adaptive measures to environmental, economic and social stressors, identified in 30 household interviews (representing 25 % of a total of 123 households in the community) and direct observations during a survey in Santa Rosa de Katta, Charazani, Bolivia (Vidaurre de la Riva, and Lindner 2012 *unpublished data*)

Stressors	Adaptive measures		
	Household	Community	External – National
• Water shortage • Drought • Hailstorms • Landslides • Fire • Biodiversity loss	• Risk management (diversification of crops) • Use of local indicators	• Rituality • Reinforcement of traditional systems • Development of irrigation systems • Traditional management of water, soil and biodiversity	• Provision of meteorological data • National funding opportunities • Technical support • Support by NGOs
• Economic system • Access to markets	• Exchange of products - *Truque* • Development and adoption of techniques and technologies in agriculture	• Temporary migration • Diversification of economics • Communal labor sharing - *Minka*	• Support by NGOs
• Erosion of traditional knowledge	• Ritual practices	• Traditional social practices	• National policy: revalorization of traditional knowledge • School curriculum incorporates traditional knowledge • Support by NGOs

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Adaptation Measures

Adaptation strategies of Andean campesinos to cope with the climatic variability – Examples from the Mantaro Valley, Peru

Gregory Amos[*]

Completed MSc.-Thesis

The climate of the Andes is changing, and those people relying on agriculture for their subsistence are particularly vulnerable. Nevertheless, and this is an asset for the Andean population, the climate in that region has always been varying, from dry to wet months, cold to warm periods of the year, and this since hundreds of years. Living in a changing and heterogeneous environment, the Andean people developed over centuries techniques to cope with the uncertainty. These techniques and strategies allow them to survive, despite more extreme climatic event.

The main objective of this thesis had three questions related to this. The first one was to identify the different strategies used by campesinos to forecast, disperse and mitigate the climatic risk. Campesinos use modern or traditional predictions, with a preference for the second, even if on a broader scale forecast seems not to be widely utilized. Among dispersion strategies, seven are commonly used. Finally, eight mitigation techniques help campesinos to reduce the effects of climatic extremes on their crops. The second question was to find out the effectivity level of these techniques, from the point of view of the campesinos. Modern forecast is either not known, or not trusted by the majority, while traditional forecast is being lost or becoming ineffective.

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Dispersion techniques are still relatively effective or widely applied, even if some of them, like storage or rotation time, are becoming an issue, the first because of pests, the latter for its shorter duration. Mitigation techniques have a very different fate: while infrastructures, like irrigation channels, or modern technologies, like chemical fertilizers, are much applied with a variable effectiveness, other strategies like terraces or Andean world view are very sporadic. The last question concerned the strategies used in the past. It is interesting to see that past and present strategies are very similar. For campesinos of the Mantaro Valley, there have been few changes in the adaptation techniques, and this proves the intrinsic effectivity of past strategies.

The danger is that campesinos start to rely only on few techniques. This is why it becomes important to promote all strategies, to guarantee a holistic risk management.

The second objective of this thesis had one question related to it, namely to know whether campesinos perceive a change in the climate. Although there are conscious about the fact that there is a normal and predictable variability, they acknowledge that in the recent years, this variability has become abnormal (i.e. there are more extreme events) and unpredictable (e.g. indicators are not working anymore).

This thesis showed that even if Andean campesinos perceive a change in the climate, they are not taking special adaptation measures, as they are already equipped with a broad set of techniques and strategies that allow them to face extreme climatic events. Of course, not all campesinos are applying all possible strategies. Actually, it is possible to find the full toolbox at a regional scale, and then at the household level one can observe that campesinos are picking up certain strategies from this toolbox. It is also very unlikely that one individual knows all possible strategies. For this reason, it is important to promote the direct exchange between campesinos.

A socio-economic analysis of livelihood strategies in rural forest depending communities in lowland Bolivia under a changing climate

Tina Bauer[*]

Ongoing PhD-Thesis

Today more than 25% of the world's population relies on forest resources. In Bolivia, the percentage is even higher as about 65 % of the country is forest covered. Not only that Bolivia faces stresses from growing population, poverty and economic development, another major uncertainty is appearing that could change many of the relationships between people and forests: The climate is changing. Exposure to climate variability and extremes such as changes in temperature and rainfall patterns result in drought and flooding. The significant effects on forest ecosystems and their provision of goods and services pose substantial risks to the safety net of the rural poor. Building resilience and adaptive capacity becomes an option for forest-depending households and communities. This research will investigate three forest-depending communities in lowland Bolivia, in terms of constraints and opportunities towards climate change adaptation and mitigation practices. With the improved under-standing and in participation with the communities scenarios will be developed. The research method bases upon the sustainable livelihood conceptual framework and the farming system approach.

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Who knows what and why? Intra-cultural knowledge variation of agroforestry plants

Regine Brandt[*]

Network Contribution

The potentials of agroforestry in climate change adaptation are widely recognized. For obtaining quantifiable data to identify adequate agroforestry plants from a socio-ecological perspective, ethnobotany provides numerous methods. They are mainly based on informant consensus and thus, focus on species that are favored by most members of a given cultural group. However, whether a plant is perceived as important or not is not equally shared. Thus, there has been growing interest in analyzing the factors that predict such intra-cultural distributions of ethnobotanical knowledge and perception. Analyzing demographic, socio-economic and cultural factors and the dynamics that are behind such intra-cultural variations are fundamental for understanding the attitudes of actors and their social relationships, which in turn affect the transmission, transformation and loss of ethnobotanical knowledge about multifunctional trees and shrubs grown in farming land. Therefore the aim is to illustrate a case study about such intra-cultural knowledge variations realized in an indigenous peasant community of the Bolivian Andes.

Related Publications:

Brandt, R. et al. (2012) Agroforestry species of the Bolivian Andes: an integrated assessment of ecological, economic and socio-cultural plant values. Agroforestry Systems 86(1): 1-16

Mathez-Stiefel, S-L., Brandt, R., Lachmuth, S., Rist, S. (2012) Are the young less knowledgeable? Local knowledge of natural remedies and its transformations in the Andean Highlands. Human Ecology 40(6): 909-930

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Traditional ecological knowledge, resilience and food security: local strategies in three communities in the Yungas ecosystem, La Paz, Bolivia

Xavier Claros[*]

Network Contribution

The present study aims at evaluating local livelihood strategies generated by traditional ecological knowledge in three rural communities located in different ecological zones (1700 - 4800 m) in the River Valley Takesi-Yanacahi, La Paz Bolivia. Communities are settled along the pre Columbian route Takesi with over 2000 years of age. The aim is to contribute to the incorporation of this knowledge in developing policies, programs or plans to improve the adaptive capacity of communities.

For analysis and characterization is of the communities we used a model of social-ecological system, whereby each community interacts with its natural environment to generate local livelihood strategies. Special emphasis was given to aspects of agro-biodiversity, cropping systems, use of local indicators of climate change, among others.

For the analysis of the strategies described produced a historical profile of the different periods from the pre Inca times to the present and found that such events have defined the current reality of the communities. Based on the profile outlined the adaptive renewal cycles were presented to the course of history and it was shown that social structures inherited from the “Ayllu” are

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persistent and provide resilience to social-ecological systems analysis.

It was noted that the diversification of agricultural and non-agricultural activities becomes the determinant of livelihood strategies and food. This diversification allows the dispersion of risk and stability of the household most of the year and therefore deals with climate, economic and productive fluctuations throughout the year.

The trends towards simplification of agro-ecosystems and production systems through the promotion of a few types of crops decreases resilience originally have traditional agro-ecosystems. So a primary action to management should be to increase the diversity and complexity to reinforce the elasticity and resilience to climate change. This tendency is currently observed in the Yungas region with the intensification of coca crops contributing factor to higher rates of deforestation.

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Influence of agroforestry systems in risk reduction and climate change adaptation in the Peruvian Andes

Presented at Tropentag 2012: Resilience of agricultural systems against crises. September 19-21, Göttingen, Germany

Francois Jost[*] *& Jürgen Pretzsch*[*]

Ongoing PhD-Thesis

Climate change as a long-term hazard is already affecting the small-scale farmers in Andean regions of Peru through extreme weather events. Weather hazards like frosts, hailstorms and droughts are affecting crops and livestock, increasing food insecurity and poverty levels.

Risk reduction and adaptation measures are one of the most urgent aspects for local small-scale farmers depending on agriculture. Although they have reduced the impacts of these hazards by adapting farming techniques, varying their crops and altering their planting season, so far not much is known about the related local knowledge, behavior and action.

The Achamayo river basin is a typical inter-Andean valley of Peru's central highlands ranging from 4500 m asl down to 3262 m asl, where agriculture remain one of the main economic activities and traditional agricultural practices are still in use. Here, droughts, more precisely, agricultural droughts during the midsummer ("veranillos") are one of the events which affect crops most directly and thus the livelihoods of the small-scale farmers in the region. Even if the mean annual rainfall has not changed significantly, there

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is a loss in the yield production due to agricultural droughts, and their incidence is increasing in the last years.

By increasing the trees and forest share in the area *i.e.* through agroforestry systems, small-scale farmers can adapt their systems to prevent natural hazards (locally mitigating their negative effects) and simultaneously contribute to climate change mitigation (increasing the storage of carbon in the system), linking both adaptation and mitigation strategies.

The main objective of the research is to analyze the use of trees as a measure of adaptation to agricultural droughts in the rural areas of the tropical Andes. The main focus is put on the relation between the presence of trees in the crops (agroforestry systems) and their influence on agricultural droughts (analyzing their effects in the yield) and consequently in the farmer's livelihood (with emphasis on food security).

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Assessing adaptation to climate change: Environmental and socio-economic changes in the Andes of Bolivia

Presented at Tropentag 2012: Resilience of agricultural systems against crises. September 19-21, Göttingen, Germany

Marolyn Vidaurre de la Riva[*] *& André Lindner*[†]

Network Contribution

Bolivia contributes only 0.04% carbon dioxide emission of the world, yet smallholders are particularly vulnerable to changing social and environmental conditions. These changes have led to an increase in food insecurity and losses in production due to drought, frost, disease, and pests. This article outlines the understanding of adaptation to climate change and its impact on environmental and socioeconomic changes that are affecting the livelihoods in communities of the Andean region. We use a case study of Charazany valley in The Apolobamba National Park; northwest of La Paz – Bolivia. Mainly qualitative methods were used to collect and analyse data following the framework for participatory vulnerability assessments. Primary data was collected at the community level applying different participatory research methods. According to the Bolivian National Institute of Statistics (INE 2010), the occurrence of extreme weather events are increasing since 2002, particularly drought, frost, hailstorms, landslides and fire. Equal observation has been made by local communities which highlight them as the principle reasons for their losses in production. Community

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members are forced to search for new off-farm alternatives beyond agriculture for subsistence, like working in construction, mining, and manufacturing (INE 2004). This means a significant impact on the structure of the families and their respective role in the agriculture activities. Nevertheless there is a correspondingly large array of possible adaptation options that families are implementing. Most of them are related to ancient traditional techniques in agriculture; as example the use of local bio-indicators to forecast the weather, variation in time and space of plantations, conservation *in situ* of indigenous crop varieties. Intensification of land use, diversification of irrigation system and water storage practices and the use of artificial products are some techniques adopted as conventional practices that can prevent losses in production. The local organization is aware of the problem, however, testimonies point out that farmers don't have the capacity or the economical resources to mitigate the risk in production. Several actions have been considered to promote the adaptive capacity; nevertheless the current target is to improve existing livelihoods and reducing vulnerability in the long term in comparable short time.

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Adaptive capacity of rural communities to climate change in the bio-cultural system of the Andes, Bolivia

Marolyn Vidaurre de la Riva[*]

Ongoing PhD-Thesis

Rural communities in the Andes of Bolivia are witnesses of the bio-cultural system changes. The lifestyle in these communities is the result of a co-evolution process between nature and social system. Yet, quality of life in these communities is highly sensitive to climate variability and change, in particular when climate changes challenge traditional relationships between social and ecological systems. Rural communities are conducting an endogenous sustainable development process based on local, governmental and non-governmental initiatives that are promoting a series of scenarios to improve the quality of life in the communities. Therefore, the present research aims to assess the contribution of scenarios on endogenous sustainable development process to the adaptive capacities to climate change in rural communities. Under the framework of vulnerability assessment to climate change a participatory approach will be conducted in different bio-cultural zones. The methodology has three main stages: (1) Vulnerability assessment at the municipality level; (2) Climate change vulnerability assessment at household level and; (3) Assessment of scenarios of endogenous sustainble development process. The main contribution of the present research is to take a step ahead on the understanding of the bio-cultural system and its adaptive capacity to cope with climate change in the Andean region of Bolivia.

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Socio-economic analysis of farm-forestry systems: Case studies from Achamayo and Palcazu watersheds, Peruvian Andes

Claudia Zuleta del Solar[*]

Completed MSc.-Thesis

From both case studies, it can be stated that each individual farm has its own specific characteristics arising from variations in resource endowments and family circumstances. Regardless of its size and the similarities with other farm household systems, it is organized to produce food and to meet household goals implementing the necessary livelihood strategies. For this reason, more profound studies in fewer case study units could be more adequate to understand internal and external interrelations.

The functioning of any individual farm system is strongly influenced by the external rural environment, including policies and institutions, markets and information linkages. Farms are closely linked to the off-farm economy through commodity and labor markets; the rural and urban economies are strongly interdependent and farmers are also linked to other communities and social networks. Altogether, these factors grouped as external determinants, influence the management of farms and consumption decisions.

A continuous transformation process influences decision-making towards natural resources. Although it occurs in both areas, when people live closer to urban centers appear to have better means to improve their livelihoods and to exchange information. Migration of new generations occurs due to better opportunities for education

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centralized in bigger cities. There is also a generalized opinion that agriculture is related to poverty.

Although agriculture is recognized by the majority as the main economic activity, tourism in Palcazu contributes to a greater dynamism of their economy. Furthermore, elements from their traditional culture revalued. In contrast, for the inhabitants of communities in Achamayo, the reliance on farming systems to sustain their livelihoods is direct and higher. Likewise, climate change negative effects, as a threat to their livelihoods, are more clearly recognized in Achamayo.

Farmers were very reluctant to give information related to wealth or income. It was observed that particularly communities in the intermediate level of the watershed are considered by the government as poor. For this reason, several governmental social programs were present in the area. Through interviews, they declared in almost every case that they only own a radio and avoided to give information about number of animals or any indicator that could be related to wealth.

The farming systems showed some degree of flexibility. Farmers where capable of finding technical solutions to problems with trees associated with crops. The lack of land could be overcome by sharing land with neighbors and dividing the income. Farming systems in these areas have the potential for poverty reduction and risk management due to climatic extreme events or other factors. Further studies could evaluate the potential technical feasibility, economic viability, social acceptability, and ecological sustainability of the solutions farmers identified.

Strong indigenous culture and high poverty incidence is found in the high altitude mixed farming system in the Central Andes (Achamayo). In contrast, in the Intensive Highlands mixed (Northern Andes) farming systems, the heartland of Andean coffee and horticulture, the prevalence of poverty is low (Palcazu).

The connection between trees and other subsystems is demonstrated. The household is supplied with fuelwood, construction materials, raw material for building fences and sheds for animals, organic matter used as fertilizer, among others. It seems that especially for elder couples, the functions of self-consumption determine their survival.

The most common farm forestry systems are trees in boundaries, wood lots and trees-horticulture-coffee systems. The main criterion for site selection of wood lots is the utilization of sites in which the soil is less fertile and not suitable for agriculture. For this reason, eucalypt and pine plantations are frequently found in upper zones with steep slopes.

Forest activities are not time nor labor demanding, and can be carried out also by elders. Farmers view the income generated by selling trees as a way to contribute and support their children and grandchildren.

Farmers pointed out that through the diverse range of uses they obtain from trees they are able to save money. *"I don't have to buy"* and *"I can save money"* were frequent statements during interviews. In addition, due to the high demand of eucalypt, many of them are able to cope with financial emergencies, when they need cash, by selling the product. In contrast, market oriented farmers were almost not interested in trees. For market oriented farmers, the contribution of trees to their livelihoods appear to be not significant.

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Monitoring and Modeling Land Use Change

Modeling and forecast of changes in land-use and land-cover caused by climate change in the Peruvian Andes

Johannes Drechsel[*†]

Ongoing MSc.-Thesis

Climate change has become an undisputed fact that has global implications. Measurement has shown an increase in the annual mean temperature in the period 1906 to 2005 by 0.7 °C. Further prognoses aspect rising global mean temperatures by 1.8 – 4.0°C till year 2100.

Especially the Andean region is already affected by the impacts of climate change, while in other parts of the world, the implications are still expected. Countries like Peru and Bolivia have already had to contend with the consequences. Melting glaciers, extreme weather events, droughts, storms and floods have a negative impact on agricultural yields and thus contribute to the impoverishment of the population. Especially smaller farms in the higher altitude areas of the Andes are affected.

Caused by climate change, conditions for agriculture are increasingly changing. A trend in rising temperatures and less rainfall can lead to a shift of the contour line and thus change the way of the management of soil.

Subject of the investigation is whether or in which way the climate change affects the local agriculture in the Achamayo watershed. Here mainly will be discussed on the effects of temperature rise of

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about 1.3°C till 2050 predicted by the National Geophysical Institute of Peru (IGP).

Central questions of the investigation are:

- To estimate the current rate of different forms of land-use/ land-cover in the Achamayo watershed.
- How is the shifting of the contour lines for the management of economically important tree species like *Eucalytus globulus* and *Polylepis sp*. and for field crops such as *Ullucus tuberosus*, *Solanum tuberosum, Cynara cardunculus* and *Lolium perenne*?
- Will rising temperatures increase or decrease the suitable area for this species?

To elaborate maps showing the current land-use and land-cover of the area in the Achamayo watershed, the methodology of remote sensing was applied. Satellite images from satellite program RAPIDEYE with high ground resolution (5m per pixel) were atmospheric corrected and topographic normalized before the supervised classification was accomplished. During the field visit from April to June over 800 points or training areas were measured for the classification of the satellite images.
Using literature research, the temperature requirements like minimum, maximum and optimum temperature was found out for each crop. Considering this information it is possible to divide the study area in land which is suitable in means of agriculture production, no suitable and possibly suitable for the cultivation of the listed species. Therefore a model, which shows the distribution of temperature in the study area, is necessary and was provided by the IGP.

Mean annual temperature decreases around 0.5°C for each 100 m increase in altitude. This fact can be used to forecast the changes in distribution of crops and therefore to estimate land-use and land-cover changes in the future.

If for instance temperature rises by 1°C the contour line of crops and trees should be expand around 200 m upwards. If temperature decreases by 1°C the contrary would happened and the contour line would reduce downwards.

Object of the work is to model these changes with the geo-information system ArcGis to elaborate maps which show the possible distribution of the listed crops and trees in the future.

Land-use and land-cover change in Cotapata National Park – Natural integrated management area, Bolivia

Daniela Limache de la Fuente[*†]

Ongoing MSc.-Thesis

Changes in land use reflect the history and, perhaps, the future of humankind. They are linked with economic development, population growth, technology, and environmental change. Understanding the dynamics of land-use and land-cover (LULC) is one of the key concepts on many urgent issues like global climatic change, food security, and loss of biodiversity, soil degradation, hydrology and even human well-being. The processes and factors associated with LULC changes are very complex, resulting from the interaction of human-environment systems which are influenced by an array of environmental, socioeconomic, policy and institutional factors. In that respect, the knowledge of the main drivers influencing the land allocation in an individual level is essential to address the establishment of conservation and development policies. In Bolivia, the rates of LULC change has experienced a steadily increment particularly during the past three decades. Nowadays, deforestation continues to represent 77% of the total land use cover change because mechanized farmers, subsistence agriculturalists, and livestock producers all preferentially select forest landscapes for conversion. On the Bolivian mountain zones, the landscape has been shaped mainly through the agriculture by

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local peasants and immigrants. One the most relevant examples of the dynamic of LULC in the mountain landscapes, is the Cotapata "National Park and Natural Integrated Management Area (NP-IMNA) (67º43'–68º02'W and 16º10'– 16º20'S), which presents a vertical transition from the Andean zones through the lowlands and where the pattern of the land use and land cover has changed dramatically since the pre-colonial era until today. The former "vertical control" of a maximum of ecological floors in the economy of Andean Communities settled inside the park has been influenced by endogenous and exogenous constraints or driving factors, giving as a result a new spatial configuration. Despite of the importance of land use and land cover change research in Cotapata (NP-IMNA), few studies have been conducted related to this aspect and most of them have been only focused on environmental, social and territorial characterization. In this sense, the aim of the present study is not just to implement a geographical approach that considers the explicit patterns of LULC change through three decades (since 1987, 2001 and 2010 to the present), but also identify relations between the driving forces at household unit that shape the current spatial configuration of the park.

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Monitoring and analyzing land-use / land-cover changes using remote sensing and GIS in the Achamayo and Shullcas region, Peruvian Andes

Fernando Medina[*†]

Completed MSc.-Thesis

The availability of remote sensing and GIS (Geographical Information Systems) technologies enables advanced analysis of land use/cover. By examining past and current satellite imagery it is possible to determine trends and therefore estimate future conversions of land use. Thus, the assessment of land use and cover changes is an important tool for landscape evaluation and for speculating possible future scenarios. It is also useful for helping in the development of management plans and policies to prevent future degradation of natural resources and to optimize land use.

The main objective of the project is to provide a description of the Achamayo and Shullcas region (Central Andes, Peru) by analyzing current and past land use/cover through remote sensing and GIS. The achievement of the objectives was done by analyzing two Landsat TM 5 images, one from 1985 and the other from 2010.

The results showed that the area is very heterogeneous and has a patchy distribution of land uses, characteristics which are already reported for other Andean sites. The most dominant land cover is grasslands where livestock grazing is the main land use. It was found that there is a decrease on vegetation density of grasslands.

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These changes might be related to overgrazing and high erosion rates. Forest plantations are mostly formed by eucalypt trees.

The increase detected in the study might be related to the reforestation projects carried out in the study area over the period of analysis. The current plantation cover is 20.98 km², representing 2.96% of the study site. It was also detected that some of these areas are missing a proper management. Urban areas have increased 17.81% from its original area over the period of analysis. The expansion took place in agricultural land which must be evaluated due to the importance of this activity in the area.

The harsh climatic conditions imposed by the altitude limit the land uses in the study area.

Agriculture and forestry are concentrated in areas below the 4000 m asl. The topography is also related to land uses in other ways. It was detected that, since tree plantations is preferably established in marginal areas (not suitable for agriculture), they were mostly located in steep slopes. Moreover, relief can also protect areas at high altitudes from climatic events (e.g. frosts and winds) thus allowing agricultural cultivation higher than 4000 m asl.

This thesis provides a description of the land use/cover in the area and points out the changes experienced since 1985. The need for management interventions in plantations is recommended for a yield increase and further evaluation of other land cover types such as grassland and “bofedales” are indicated.

Climate change and land-use in the Bolivian Andes

Omar Torrico[*]

Intended MSc.-Thesis

Nowadays there is a strong consensus that climate change represents an urgent challenge for the well-being of all countries, especially in those where the poorest people is living. Advances in climate science have enabled climate modeling to provide a view of the future of the earth system on a global scale. However, different areas and environments are affected in a distinct way and its precise implications predictions of rainfall rates, the likely frequency of weather events, and changes in weather patterns still remain unclear.

The Andean region will be one of the most impacted areas by climate change over the next 15 years. In Bolivia smallholder farmers and indigenous peoples are already experiencing climate-related vulnerabilities. As their livelihood depends on natural resources, they are the first communities to observe climate and environmental changes by first-hand, and they have already been adapting their traditional knowledge, land use and survival strategies. It is important to study the main causes that are contributing to climate variation and its impact in rural communities in Bolivia. The changes in land use constitute one important anthropogenic force that influence in regional and global climate variation.

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Therefore the main objectives of the research proposal are:

- To assess the land use patterns (forest coverage, glaciers surface, expansion of agricultural zone, use of ancestral technologies), climate variations, and its impacts in social dynamics through the use of Remote Sensing, Geographic Information System and field research (direct observations) in the selected area of Bolivian Andes.
- To characterize and describe the agricultural use, vegetation, ecological levels and use of ancestral technologies at different altitudes in the study area.
- To describe the land use patterns and its correlation with climate variability over the time.
- To analyze the impacts of the land use change, weather variability in social dynamics (e.g. migration, agriculture shifting) over the time.

GIS instruments and structured interviews will be implemented in the study area. This will allow to provide data and perceptions of rural communities in regards to the productivity systems, climate variability, land use, and impacts (variables to be defined) over the time (20-30 years). This will include gathering data from significant weather stations in the research area and the records from the Meteorology and Hydrology National Service, as well as the rainfall data analysis, relative humidity and daily temperature in the last few years. This information will be systematized by reports and production of maps.

Modeling the adaptation strategies of farmers of the Andes against climate change and the related development of land-use / land-cover

Presented at Tropentag 2012: Resilience of agricultural systems against crises. September 19-21, Göttingen, Germany

Mariana Vidal-Merino[*], *Thomas Berger*[†], *Jürgen Pretzsch*[‡], *Uta Berger*[*]

Ongoing PhD-Thesis

There is a strong demand from policy makers for predictions about the impacts of climate change and the effect of potential adaptation responses on the local scale. This can be a difficult task, especially when dealing with highly complex socio-ecological systems. This paper discusses the suitability of agent-based-models (ABMs) for such a task. Formally, agent-based modeling is a computational method that enables a researcher to create, analyze, and experiment with models composed of agents that interact with each other within an environment.

The research uses mathematical programming-based multi-agent systems (MP-MAS), an ABM software application for simulating land use change in agriculture and forestry. We use MP-MAS for assessing the development of farming systems under potential climate change scenarios in agricultural systems of the Andes of Peru. MP-MAS couples a cellular component representing a physical

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landscape with an agent-based component representing land-use decision-making. The uniqueness of MP-MAS lies in the fact that it incorporates whole farm mathematical programming to simulate land use decision-making.

A prototype was implemented with the data available from the INCA project in the Achamayo watershed located in Junín, Peru. As environmental driver of land use change the model used information about daily average, minimum and maximum temperature of the last 30 years to predict three different scenarios for the year 2050. Main land uses included agriculture, grasslands, forest plantations and urban areas. Preliminary results show in all scenarios an expansion of the agricultural land while grasslands decrease in total area and also in quality (with more grassland area categorized as "low density"). Between the adaptation responses of farmers, agroforestry was the one with a higher increase.

Further model development considers water availability as abiotic driver of land use change, market forces, as well as potential policy interventions (*e.g.* credit, subsidies) for local livelihood improvement. The relative impact of these drivers on systems dynamics will be discussed.

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Management of a Changing Landscape

Evaluating the strategies for the management of biophysical resources in farm communities of the Mantaro Valley, Central Andes of Peru

Keynote

Sady Garcia Bendezu[*]

Network Contribution

Agriculture in the Central Andes of Peru is performed mostly by small farmers in mixed crop-animal production systems. Farmers are organized in collaborative social structures named Farm communities, in which complex mechanisms for access to land, labor and inputs can be found. Most of the previous research in the region has focused on specific physical and biological topics (climate, soils, biodiversity), with limited integration to the existing social structures. This work aims to develop a holistic view of the farming systems in four farm communities in the Mantaro Valley (Central Andes of Peru) by investigating all biophysical inputs and outputs at the field level on quantitative scales, and providing information for future implementation of strategies to increase the farm technical sustainability.

The present work was developed from 2004 to 2008, in the research sites of Colpar, Quilcas, Aramachay, Sincos, Molinos and Quero. The experimental data were collected using participatory research methodologies and structured interviews of farmers combined with farm visits and intensive measurement of selected pilot-plots. The climate during the experimental period was measured through semi-automated weather stations.

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The crop cycles managed in 38 plots along three crop seasons were categorized in terms of use of organic and inorganic nutrient inputs. The inorganic fertilizers used were measured and the organic matter sources were chemically characterized. With these data, the production of biomass and the inputs and removals of carbon, nitrogen, phosphorus and potassium were measured, and nutrient balances were calculated. The use of labor, animal traction and machinery were measured per plot. The amount of animals raised per farm was recorded at the beginning of the study. Biomass production and C- and N-balances were further calculated for the main rotations identified.

The precipitation in Mantaro Valley is concentrated in a well-defined rainy season extending from October to March. The dry season is colder, but the diurnal variation of temperature is much wider than the yearly variation. The major climatic risks during the crop season are the occurrence of drought periods and frosts. The risk of frosts is highest in Aramachay, resulting in the replacement of corn by barley in the crop rotations. The overall climate is adequate for annual crops, but without irrigation to overcome the dry season it is impossible to establish permanent crops.

Two main groups of soils were indentified in the studied zones: soils located on hillsides, which are fine-textured, moderately fertile, high in organic matter and acidic; and soils located on the valley floor, which are coarse-textured, chemically fertile, low in organic matter and slightly alkaline. The unfavorable chemical properties in the soils identified can be remediated with regular soil management practices. Soil fertility can be increased through the application of organic matter and rational use of inorganic fertilizers. Phosphorus and potassium deficiencies did not seem to be critical. As strongly acidic soils are common, liming could result in increased yields for barley and legumes. Soil chemical properties are not strong limiting factors for the production systems.

Crops included potatoes, cereals, corn, grain legumes and native tubers. Potatoes received the highest amounts of external inputs (organic and inorganic) but yields obtained varied widely in relation to the inputs applied. In general, the C- balances were variable and the N-, P- and K-balances were positive, indicating that, in certain cases, potato plots were over-fertilized. Barley and wheat were cultivated with fewer inputs compared to potato, while corn and faba-bean fertilization consisted mainly of farmyard manures. C-balances in cereals and corn were strongly negative, and nutrient-balances depended on the amount of fertilizers applied. C- and nutrient-balances were positive for faba-bean. Crop production systems in Colpar are oriented to organic matter use while in Molinos production is based on inorganic fertilizers. Quilcas, Aramachay and Sincos have mixed-input systems.

Livestock included cows, oxen, sheep, donkeys, guinea pigs and poultry. Animals are fed with natural pastures during the rainy season and with fodder and crop residues during the dry season. Crops fertilization depends on farmyard manures, thus crop production is strongly related to animals. Most of the farmers prepare farmyard manure according to one traditional procedure. Manure accumulates during the dry season, when most of the animals stay in the stable.

In all the zones, land is split in small units to diversify cropping and diminishing climatic risks. The plots are usually larger in the flat areas. The availability of land per farm is markedly lower in Colpar and Quilcas compared with other zones. Human labor, especially obtained from family members, is the main source of energy for crop cultivating activities. Exchanged labor was more frequently observed in Colpar and Quilcas and contracted manpower was used more in Molinos. Both male and female laborers had the same importance for crop management, although they could be divided according to specific activities. Animal traction was used extensively for soil preparation and transport, especially in high altitude zones.

The use of machinery was limited to low and flat areas where plots were larger and accessible. Crop production in Colpar was totally dependent on human and animal labor, while Molinos used more machinery.

Monocultures of cereals or corn and rotations with potato were negative in C-balances, but the N-balances were positive. The inclusion of faba-bean in the rotation resulted in positive C- and N-balances. Fallow periods could restore C and N in the system, but their contribution was lower than that for legumes. Partial transfer of inputs from potato to barley and replacement of fallows with grain or forage legumes are proposed as strategies for increasing sustainability of rotations.

Soil liming and inorganic fertilization increased grain yield of barley, indicating that transferring fertilizers from potato could result in a better use of nutrients within the rotations in farm communities in the Mantaro Valley.

Participative planning, monitoring and evaluation system in bio-cultural local communities

Maria Cristina Ruiz[*], *Karina Rodriguez-Auad*[*], *Rodrigo Tarquino*[*]

Network Contribution

The Biocultural National Program at Bolivia (throughout 2010 to 2014) try to achieve ecosystem conservation and "Vivir bien" of the local communities in Andes region from Bolivia, applying the sustainable management of biodiversity and appreciation of local cultures. This program based on three key concepts:

- Biocultural approach, which raises the interrelationship between biodiversity and culture
- "Sustainable endogenous development"
- Philosophical principle of "Vivir Bien" is the fundamental principle of the Bolivian Government Development Plan (2006 – 2010).

The last point needs 2 phases for the implementation: The first phase is the gathering of information and documentation of the data baseline in 32 municipalities grouped in 24 Endogenous Bio-cultural Systems (EBS). The second phase is the design of a monitoring system and the evaluation of results.
Currently 17 EBS are implemented with varying degrees of fulfillment and the remainder will be implemented during the end of 2012.

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All projects implemented in the EBS´s, are monitored every six months and evaluated annually. The purpose of the implementation of the EBS´s is to search for an interface between development and the principle of "Vivir Bien" from and within local communities, involving the interrelation of the natural, social and spiritual components.

The monitoring program in Apolobamba protected area

Rodrigo Tarquino[*]

Network Contribution

The natural integrated management area Apolobamba (AP) is a protected area that has a high altitudinal variability resulting in a high biodiversity in addition to a strong “Kallawayas” culture. The AP requires first-hand information for decision-making; therefore, a monitoring program was established to determine the “health status” of this protected area and to perform a management based on adequate information. The monitoring program was designed in a participatory manner and includes 24 indicators of monitoring. During the implementation process currently 20 of them are monitored. Furthermore the lessons learned during this process will be helpful for replication in other protected areas. The overall objective is to share the experience in design and implementation of successful monitoring program in the Apolobamba protected area.

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Progress in the diagnosis of biodiversity vulnerability to climate change in Bolivia

Prem Jai Vidaurre[*]

Network Contribution

Within the context of the national mechanism of climate change adaptation (National Program of Climate Change - PNCC), the aim is the assessment of biodiversity vulnerability to climate change in Bolivia based on secondary information. The present paper is a report of the accomplishment of two objectives: (1) Definition of the unit of analysis to identify the impact of climate change in biodiversity. (2) Description of the main impacts of climate change in biodiversity. Therefore, a workshop with experts on ecosystems, biodiversity, and climate change from different national institutions was conducted.

The eco-regions of Bolivia were selected as a macro unit of analysis due to the information available. At the same time, an assessment of institutional publications from IPCC, CDB, PNCC and others was conducted. The analysis shows the principal impact of climate change at ecosystem level. The vulnerability of the ecosystems to climate change is reflected by altering species compositions and changes in species ranges. Furthermore, there is an anthropogenic impact on the ecosystems; for example: deforestation, land-use change into agriculture, mining and others. Such activities are accelerating the process of ecosystem degradation. Thus, ecosystem services like climate regulation and availability of natural resources diminish.

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Sectoral program of adaptation to climate change of biodiversity and ecosystems

Prem Jai Vidaurre[*]

Network Contribution

By the National Program of Climate Change (PNCC) the Vice-ministry of Environment, Biodiversity, Climate Change and Forestry Development promotes the "National Mechanism of Adaptation to Climate Change" (MNACC). The main objectives are to reduce vulnerability to climate change in different sectors, to encourage stakeholders to adapt, to develop adaptation measures and to ensure an appropriate risk management. The structure of the MNACC has five sectoral programs: (1) Food security, (2) Health, (3) Water resources, (4) Ecosystems, and (5) Human settlement and risk management.

The sectoral program of adaptation to climate change of biodiversity and ecosystems has the aim to define strategies to be able to integrate the topic of climate change within the conservation policies and sustainable use of biodiversity from the ecosystem perspective. This program has 4 principal components: (1) Incorporation of climate change in the planning and sectoral legal framework (2) Training and research of the threats, impacts and vulnerability of biodiversity to climate change, (3) implementation of adaptation measures on biodiversity at ecosystem level, and, (4) proposed the implementation of adaptation measures from protected areas.

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Deforestation and Climate Change

Possible interactions between climate projections and deforestation scenarios in Bolivia

Ruben Mamani-Paco[*]

Network Contributions

Climate projections of models are compared with different deforestation scenarios in Bolivia. Precipitation, temperature and deforestation trends are evaluated to see possible interactions and direct effects on greenhouse gas emissions. Change of land use is currently the primary source of greenhouse gases in Bolivia and it is mainly driven by expansion of the agricultural frontier. Local impacts on biodiversity loss are considered. Possible policies to help mitigate and adapt to these trends are discussed.

Transport and possible climate impacts of aerosols from biomass burning from the Amazon to the Bolivian Andes

The transport of aerosols from biomass burning was studied using a MOUDI impactor to collect atmospheric particles differentiated by size. Samples were taken at the source and at the Chacaltaya Mountain research station during seasons of influence and non-influence of plumes from the Amazon region. Back trajectory models were run to estimate air mass transport from the Amazon to the sampling site. We concluded that there is evidence of aerosol transport from biomass burning and that this transport influences local atmospheric radiative effects which might affect glacier retreat in the tropical Andes.

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Transboundary air pollution in southern Amazon of Peru

Luis Suarez[*]

Network Contribution

Biomass burning is the main source of pollution in the tropical region, covering huge areas in Amazon basin. Special concern exists in the border of Peru, Bolivia and Brazil where big land areas area cleared and burned every year, as part of an increase of agriculture areas for commercial crops. The pollutants resulting from this burning mainly in the region of Brazil, where more fire activity is identified, could travel thousands of kilometers by the predominant winds to the Peruvian territory.

We implemented three locations for monitoring: Oxapampa, Mazamari and Manu, covering the southern part of the Peruvian Amazon. Satellite information was used for complement monitoring of aerosols and tropospheric ozone. Ground measurements collected aerosols for later evaluation of the elemental chemical composition. Finally, we used HYSPLIT model to evaluate trajectories of air pollutants to identify sources of pollution. During the sampling campaign it was possible to detect the seasonal variation of aerosol and tropospheric ozone over the Amazon basin of Peru, Bolivia and Peru. There was a strong modification of elemental concentration mainly related to biomass burning tracers like P and K, and also related to crustal Ca and Si. The combined use MODIS and CALIPSO satellites provide a deeper understanding of the aerosol content in the atmosphere. Special attention was done for pollution during September 17th 2008, the day with the highest value for Aerosol Optical Depth of MODIS (0.741).

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Summary

Challenges presented by climate change in the Andean region: Land-use cover change and adaptive response of small farmers

Presented at Tropentag 2012: Resilience of agricultural systems against crises. September 19-21, Göttingen, Germany

Mariana Vidal-Merino[*], Francois Jost[†], Gregory Amos[†], Fernando Medina[†], Jürgen Pretzsch[†], André Lindner[†], Uta Berger[*]

Summary & Outlook

For people living in the Andean Mountains, climatic change is not a problem of the future - they already face the effects. The Andean region of Peru is bearing the consequences of climate change, such as retreat of glaciers and extreme weather events, which are increasingly affecting the livelihoods of small local farmers and increasing the vulnerability of the farm systems they depend on.
This paper presents the first results of the "International Network on Climate Change in the Andean Region (INCA)" project. The INCA is a scientific network specialized on climate change that seeks to understand the situation of local farming and forestry systems in the Andean Region, deriving and testing livelihood strategies for farming systems and indigenous communities.

First results of the INCA project, based on research in the Achamayo Watershed in Peru, include:

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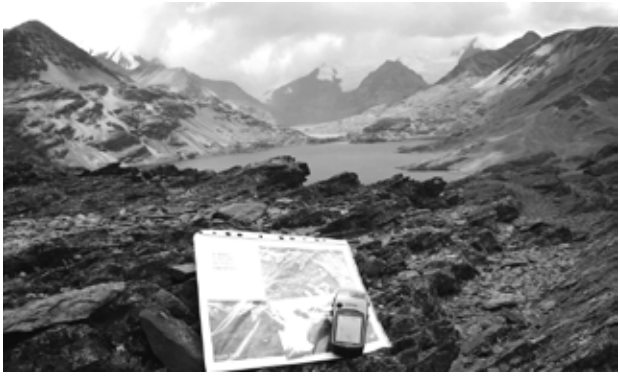
- A study of the perception of local people towards the development of climate over the last 10 years
- An analysis via satellite images and field research on land use cover/change since 1921
- An assessment of the adaptation strategies available and used by small-scale farmers

Project results show that farmers are well aware of the ongoing changes in weather patterns, signaling the occurrence of frosts and heavy rainfall as main causes of agricultural loss. The decrease of water springs during dry season was reported to have a direct impact on the livestock which rely on natural grasslands as main fodder source. The analysis of land use cover change supported this former statement, reporting severe grasslands degradation, with 21.26% decrease of the "high density grassland" land cover since 1921. Concrete strategies to forecast, disperse and mitigate the climatic risk were identified.

Ongoing research within the INCA project applies modeling techniques for assessing the development of farming systems under potential climate change scenarios and the consequences of the resulting land use mosaics on economical utilities (food security and income) and environmental services.



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IADB - Inter-American Development Bank	UAP - University Alas Peruanas, Peru
MLU - Martin-Luther University, Germany	UMSA - University Mayor San Andres, Bolivia
MU - Makere University, Uganda	UNALM - National Agrarian University La Molina, Peru
SUA - Sokoine University of Agriculture, Tanzania	UOK - University of Kordofan, Sudan
TNC - The Nature Conservancy	USP - The University of the South Pacific, Fiji

Welt im Wandel – global denken, lokal handeln

Wissenschaftler aus Bolivien, Peru, Äthiopien, dem Sudan, Tansania, Uganda und Deutschland trafen sich an der Fakultät für Umweltwissenschaften auf dem TU-Campus in Tharandt zusammen. Foto: Archiv Feger

Internationales Klimanetzwerk vereint Forscher aus Afrika, Südamerika und Deutschland in Tharandt

Rund 50 Wissenschaftler aus Bolivien, Peru, Äthiopien, dem Sudan, Tansania, Uganda und Deutschland kamen Ende September an der Fakultät für Umweltwissenschaften auf dem TU-Campus in Tharandt zusammen. Sie diskutierten gemeinsam die Herausforderungen und Konflikte in Zeiten des globalen Wandels und tauschten hierzu regionen- und kulturenübergreifend Erfahrungen und Erkenntnisse aus. Die Forscher sind als Partner an zwei internationalen Kooperationsprojekten an der Professur für Tropische Forstwirtschaft unter Prof. Jürgen Pretzsch am Institut für Internationale Forst- und Holzwirtschaft beteiligt. Diese Projekte untersuchen die Auswirkungen klimatischer Veränderungen in tropischen Regionen, um Anpassungsstrategien zur Stärkung lokaler Bevölkerungsgruppen zu identifizieren und nachhaltige Lösungsansätze zu erarbeiten. Die integrierten sozio-ökonomischen Ansätze werden kontinuierlich begleitet durch naturwissenschaftliche Untersuchungen zu Wasser- und Bodenressourcen (Institut für Bodenkunde und Standortslehre, Prof. Karl-Heinz Feger) sowie zur Ökologie (Institut für Waldwachstum und forstliche Informatik, Prof. Uta Berger).

Das aus Mitteln des Auswärtigen Amtes finanzierte und vom DAAD unterstützte Projekt »International Network on Climate Change« (INCA), läuft bereits seit 2010. Der geographische Fokus liegt hier auf der Anden-Region in Südamerika. Im Juli 2012 startete das afrikanische Netzwerk »Scientific Cooperation Network on Climate Change Adaptation« im Rahmen des vom Bundesministerium für Bildung und Forschung geförderten DAAD-Programms »Welcome to Africa«. Vorrangiges Ziel ist hier eine Stärkung der Hochschulkooperation mit Partnern in der ostafrikanischen Region. Beiden Netzwerken gemein ist ein intensiver Austausch in Form von Workshops und Forschungsaufenthalten von TUD-Studenten und Doktoranden in den Zielländern.

Die interdisziplinäre Forschung der TU Dresden begibt sich dabei direkt an die Orte des Geschehens, in Regionen, die vom globalen Wandel schon heute unausweichlich betroffen sind. Zu den Herausforderungen, die es zu bewältigen gilt, zählen drohende Armut, Wasserknappheit, Gefährdung der Nahrungsmittelsicherheit, Naturkatastrophen und aufkommende Konflikte um schwindende natürliche Ressourcen. Gemeinsame Ziele bestehen darin, Forschungsergebnisse zu bündeln und relevante künftige Forschungsthemen zu benennen. Diese sollen den internationalen wissenschaftlichen und entwicklungspolitischen Diskurs voranbringen und Anstoß für künftige gemeinsame Forschungsprojekte geben. INCA und »Welcome to Africa« stehen für vielversprechende Kooperationen an der TU Dresden, welche die Internationalisierung und globalen Vernetzung im Zuge der Exzellenzinitiative unterstützen.

Maxi Domke / Dr. André Lindner

www.forst.tu-dresden.de/INCA
www.daad.de/welcome-to-africa

Article published in the campus-journal of the Dresden University of Technology about the Summer-School and the joint-meeting of both, the South-American and African climate change network

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INCA International Network on Climate Change

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DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service


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